## VI.—*On some experiments made at H. M.'s Mint in Calcutta on coining Silver into Rupees.—By* Col. J. F. Tennant, R. E., F. R. S., &c., *Master of the Mint.*

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It has long been known that when an alligation containing fine silver and copper has been melted the result is an apparent refining, and the result of the further processes in coining is also to change the constitution of the alloy. In order, therefore, to produce Rupees of standard weight and fineness, it has always been found necessary to allow for these changes. The rule by which this allowance was made, however, did not seem to me to have any good foundation, and, while generally speaking the results were fair, there were occasional departures which convinced me that it could be improved. The rule here has been to make the alligation to standard $\frac{11}{12}$ of silver: scissel being assumed to have this fineness—then copper was added in proportion to all the silver except scissel, so as to reduce the fineness and this "extra alloy" was subject to variation on different coins.

It was clear then that silver in the form of scissel was not supposed to refine, and next that the whole of the change was not supposed to occur in melting, but partly to depend on the further processes. The last was a matter which was evidently more than probable; and as regards the first Col. J. T. Smith, late Master of this Mint, had many years ago shown that after a time a silver alloy ceased to refine. It seemed to me more than probable that this last result was only an approximation to the truth, and that the fact was that copper when mixed (at all events in small quantities) with silver was not exposed to oxidation in the furnace; but on this hypothesis it became absurd to add extra alloy on silver of 900 milliémes of fineness as on fine bars. I thought too that I saw that the variations which such an error would cause really took place, and resolved therefore to investigate the whole matter experimentally.

Silver at this Mint is reported to 0·2 of a milliéme: when an alligation is made, it is usually arranged that there shall not be a great number of finenesses used, and as each quality will be composed of several samples, these are all mixed in a heap, so that the silver used is the average (roughly) of several samples all reported alike. This procedure generally allows all the pots of a day's melting to be practically identical in fineness and weight, and if this be not the case it is very rarely that there are not several similar pots. There were no cases of single pots in this work, though owing to a small stock of silver, the whole in each melting could not be made alike.

Having the weight and fineness of each sample of silver in a pot, we are in a position to compute its fineness on the supposition that no change takes place in melting : this I call the "*Theoretical Fineness.*" When the contents are melted and well mixed, a small spoonful of the fused alloy is granulated and from this a muster is delivered to the Assay Master : the fineness of this I have called the "*Fineness of Pot,*" it is generally greater than the Theoretical fineness. In the later processes and especially in that of "pickling," preparatory to coining, the fineness is further increased, and the final result is determined from an assay of the coins by taking a proportion of coins for assay singly, and also some for assay after melting them up. This last determination is the least satisfactory ; however uniform the melted mixture may be, the alloy is not equally distributed in the resultant ingots and every after process tends to increase this irregularity ; so that at last, not only are the various coins different in their fineness, but portions taken from different parts of the same coin are so. I have used as a measure of the fineness of the coins of one day, the mean result derived from 20 single coins—the sample piece being always cut out from the centre of the coin, and I have called the result "*Fineness of Coins.*"

During these experiments 10 pots were daily alligated to the same *Theoretical Fineness* : I have thus had a measure of the accuracy of the Assay Reports, and I have used this for calculating the probable errors of the theoretical finenesses, in a way which (though somewhat arbitrary) seems to me sufficiently accurate for the purpose. When the probable error of an Assay Report is known, it is easy to calculate that of one heap, made of several samples of one quality, on the supposition that the whole is fairly mixed. As, however, the mixture must at best be very imperfect, I have preferred assigning to each quality of silver the same probable error of fineness as though all had depended on a single report.

As any erroneous hypothesis as to the quality of scissel used would clearly have vitiated the results, I had a quantity melted down, assayed, and laminated, each pot being kept separate, and thus I had metal which was of known fineness—save the small change from lamination which would equally be shared by all scissel—but which I conceived would be subject in melting to the same changes as scissel itself.

I had intended to keep the work from each pot separate all through, but after a certain point this was found impracticable, and the coins from a single day's melting have been mixed. After I had completed the greater part of the calculation for this paper, I found that, by a careless blunder, there had been a mixing of the coins of the second and third days' meltings : and though I could only prove that it had been slight, and it probably would not have seriously affected the result, I had the work of those days repeated and I use this repetition, though the results are not nearly so accordant as those I first had. This is the reason why the melting numbers do not run continuously from 89 to 98; 90 and 91 being omitted and 114 and 115 inserted.

The following table shows the mean results for each day's work with their probable errors; the quantities of scissel and copper used daily are approximately shown. The unit of weight is a tolah of 180 English grains. A pot contains close on 12,500 tolahs, or 4687.5 ounces troy, and the whole quantity of standard silver melted and watched was about 12,45,000 tolahs, or 466,875 ounces troy, or about 14,521 kilograms. What is not accounted for as scissel or copper was refined bar silver of about 997 fine. The scissel was about 916 fine.

| Melting No. | Composition. | Fineness in millièmes | | | Gain in fineness. | | |
|---|---|---|---|---|---|---|---|
| | | Theoretical. | of Pots. | of Coins. | Pots — Theory. | Coins — Theory. | Coins — Pots. |
| 97 | All scissel,<br>No copper, | 915·80 ± 0·078 | 915·82 ± 0·041 | 916·34 ± 0·080 | 0·02 ± 0·088 | 0·54 ± 0·112 | 0·52 ± 0·090 |
| 98 | All scissel,<br>No copper, | 915·80 ± 0·058 | 915·63 ± 0·038 | 916·35 ± 0·089 | —0·17 ± 0·069 | 0·55 ± 0·106 | 0·72 ± 0·097 |
| 89 | 9563 scissel,<br>186 copper, | 916·47 ± 0·079 | 916·83 ± 0·032 | 917·40 ± 0·086 | 0·16 ± 0·086 | 0·73 ± 0·117 | 0·57 ± 0·092 |
| 115 | 10100 scissel,<br>189 copper, | 916·42 ± 0·049 | 914·36 ± 0·027 | 917·30 ± 0·085 | —0·06 ± 0·056 | 0·88 ± 0·098 | 0·94 ± 0·089 |
| 114 | 7529 scissel,<br>404 copper, | 916·19 ± 0·057 | 916·75 ± 0·018 | 917·05 ± 0·078 | 0·56 ± 0·060 | 0·86 ± 0·097 | 0·30 ± 0·080 |
| 92 | 7512 scissel,<br>407 copper, | 916·20 ± 0·069 | 916·31 ± 0·019 | 916·89 ± 0·093 | 0·11 ± 0·072 | 0·69 ± 0·116 | 0·58 ± 0·095 |
| 93 | 5002 scissel,<br>611 copper, | 915·96 ± 0·066 | 916·72 ± 0·022 | 917·07 ± 0·041 | 0·76 ± 0·070 | 1·11 ± 0·078 | 0·35 ± 0·047 |
| 94 | 5004 scissel,<br>609 copper, | 915·95 ± 0·066 | 916·80 ± 0·032 | 917·20 ± 0·077 | 0·85 ± 0·073 | 1·25 ± 0·101 | 0·40 ± 0·083 |
| 95 | 2501 scissel,<br>826 copper, | 915·71 ± 0·074 | 916·05 ± 0·018 | 916·87 ± 0·080 | 0·34 ± 0·076 | 1·16 ± 0·109 | 0·82 ± 0·082 |
| 96 | 2523 scissel,<br>816 copper, | 915·72 ± 0·074 | 916·65 ± 0·029 | 917·28 ± 0·097 | 0·93 ± 0·079 | 1·56 ± 0·122 | 0·63 ± 0·101 |

It will be seen that two meltings have been made for each proportion of copper. If C represent roughly one hundred tolas of copper, and we group these determinations in proportion to the quantity of copper, we shall have :

| | Gain in | | |
|---|---|---|---|
| Copper. | Pots — Theory. | Coins — Theory. | Coins — Pots. |
| 0 C | — 0·075 ± 0·079 | + 0·545 ± 0·109 | + 0·620 ± 0·094 |
| 2 C | + 0·050 ± 0·073 | + 0·805 ± 0·108 | + 0·755 ± 0·091 |
| 4 C | + 0·335 ± 0·065 | + 0·775 ± 0·107 | + 0·440 ± 0·088 |
| 6 C | + 0·805 ± 0·071 | + 1·180 ± 0·090 | + 0·375 ± 0·065 |
| 8 C | + 0·635 ± 0·078 | + 1·360 ± 0·116 | + 0·725 ± 0·092 |

It is evident that the refining of the Pots from the Theory is nearly proportional to C, and that the refining of the Coins above the Pots or the ingots is approximately constant, though irregular, as indeed might have been anticipated.

If now we assume $a + mx$ to be the refinage in melting, when $m$ is the coefficient of C above, and $y$ to be the refinage in passing from the Ingots to Coin ; we shall have

5 values of $a + mx$ of nearly equal weight
5 ——— $y$ of sufficiently equal weight

and 5 values of $a + mx + y$, which being the sums of the others we may neglect.

From these equations we get the following values :

$$a = - 0{\cdot}085 \pm 0{\cdot}088$$
$$x = + 0{\cdot}109 \pm 0{\cdot}018$$
$$y = + 0{\cdot}583 \pm 0{\cdot}051$$

The large probable error of $a$ compared with its value renders it very doubtful if there is any real change in scissel melting. What there is seems to be towards *loss of fineness* and it is quite certain that silver evaporates ; for, in the Regenerators and flues of the Gas Furnaces (now disused) the soot was found to contain silver.

The other quantities are clearly marked, and the small probable error of $x$ shows that the hypothesis that free copper only burns is probably true. Had $a$ been assumed = 0, the value of $x$ would have been 0·095.

The value of $x$ shows that sufficient copper burns away to raise the fineness by 0·109 millièmes for each 100 tolahs of free copper and this quantity should be added as extra alloy: and the value of $y$ shows that, during the processes of converting ingots into coin, sufficient alloy is removed to make the coins 0·583 of a millième finer on the average than the ingots from which they are made.

Thus in order to have accurate Rupees it would seem necessary that the Calculated or Theoretical fineness of the pots should be

$$916{\cdot}667 + 0{\cdot}085 - 0{\cdot}583 - 0{\cdot}109\ \mathrm{C}$$
$$\text{or } 916{\cdot}169 - 0{\cdot}109\ \mathrm{C}.$$

Now if S be the amount of pure silver in a mass and W be its weight, the fineness $f = \frac{\mathrm{S}}{\mathrm{W}}$ and $d\mathrm{W} = -\frac{\mathrm{W}}{f}\,df.$

If in this equation we put $\mathrm{W} = 12{,}500$, $f = 0{\cdot}916667$ and $df = 0{\cdot}000109\ \mathrm{C}$, we shall have $d$ W or the additional alloy $= 1{\cdot}48$ C.

Practically then to get Rupees of standard fineness we should alligate to 916·169 and then add $1\frac{1}{2}$ per cent. of the free copper.

For smaller coins the increase of fineness will be greater and the alligation will be lower.

When the alloy in the silver is at all volatile or very oxidable the above rule would not serve of course. So far as possible it is sought to guard against this by melting all low-touch or suspicious silver before receipt and heating it strongly; or even, in some cases, partially refining it.

The probable error of the fineness of the pots for any one day is deduced from 10 reports of as many pots assumed to be alike. Its mean value is 0·0276 of a millième. Hence the probable error of the report of a pot is 0·087* of a millième. As each report is the mean of two single assays, the probable error of a single assay will be 0·123 millièmes.

Again, the probable error of coins used above is derived from 20 single assays of coins; its mean is 0·0806 millièmes, thus the probable error of a single coin assay on the mean of all will be 0·360 millièmes. This probable error is the probable error of a single assay combined with the probable error of a single coin as compared with the mass from which it is taken. The former has been found 0·123 millièmes, hence the latter will be 0·139 millièmes.

Again, it is customary here to check the single assays of coins daily by a double assay of the melted mass resulting from 20 coins spoilt in the stamping presses. The probable error of each such report is combined of the probable error of the mean of 20 coins together with that of a double

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* I have assumed that 0·1 of a millième is a sufficient approximation in valuing the Theoretical fineness.

assay, or is 0·116 millième. The usual daily check is one such report from a melting and 10 from single assays of coins, and, as the probable errors of these values are 0·116 and 0·114 respectively, it is evident that they are practically of equal weight: when so taken the probable error of the mean fineness of a day's work will be 0·081 millième.

In receiving Bullion about seven separately assayed parcels make a lac (1,00,000) of Rupees in value. The probable error of an assay report has above been found to be 0·087 millième and that of a lac (in value) of Bullion 3·29 Rupees from assay only. The probable error of a lac of coinage is 8·1 Rupees from its assay, which shows that even for this small daily outturn, the valuation is not sufficiently good; and the uncertainty increases in proportion to the outturn, while that of the intake does not increase so fast.

With 1 lac of outturn the probable error is 2·47 that of equal receipt
2 " " 3·50 " "
3 " " 4·27 " "
4 " " 4·95 " "

In order that the assay valuations of receipt and outturn should be similar, the coinage should be only 63,600 Rupees daily.

If these checks stood alone, it would be impossible for a Mint Master to feel any confidence in his work. And an assay establishment sufficiently large to value a heavy coinage thoroughly, and to make the necessary assays of single coins would be very expensive. The assays of pots are a very valuable test in a large coinage, especially when, as here, they are made nearly uniform in composition and thus check each other. In practice a coin beyond the legal remedy of two millièmes in fineness is almost unknown, but the law is now probably as exacting as it is possible to make it.

I am very greatly indebted to Mr. Edis, who was acting as Assay Master of this Mint, for the attention and skill he gave to these assays, which were more in number than the amount of work ordinarily would have called for. The accuracy of his work is proved by the small probable errors.

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To obtain these data was the primary object of my experiments: incidentally, however, the weighments which are made in passing the metal from hand to hand furnish some interesting information as to the general working of the Mint which I purpose here to place on record.

The unit of weighment is a tolah (the weight of a standard rupee) of 180 grains, which is here decimally divided: 8 tolahs are equivalent to 3 ounces Troy; the English Pound contains 38·88889 and the kilogram 85·73526 tolahs. And hence—

1,00,000 Rupees should weigh 1,00,000 tolahs.
" 37,500 ounces Troy.
" 2,571·4296 Pounds = 1·14796 Tons.
" 1,166·3811 kilograms.

The Melter receives his silver in bars and lumps, and also as scissel and rejected blanks and coins. The portions for each pot and its proportion of copper are separately delivered. His results are—

1*st.*—Ingots which can be weighed as soon as cleaned.

2*nd.*—Chippings from the bars and spillage which require to be cleaned before weighment: usually next morning.

3*rd.*—Ends of ingots and pieces cut off before delivery to the laminator as not being fit for straps.

4*th.*—He has drosses and sweep which contain more or less silver and of which the value cannot be known till later.

The following table shows the results obtained in this department from these experiments, as to which it must be noted, that while the metal is accurately weighed to the Melter, the future weighments are less accurate until it takes the form of coin, for it would be impossible to give the same time and care to weighments which are mere checks that are necessarily given to the more important ones; or to use balances for them as delicate.

| Melting No. | Weight given to Melter. | Outturn. | | | Approximate Loss. |
|---|---|---|---|---|---|
| | | Good Ingots. | Heads and Pieces. | Particles. | |
| | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* |
| 89 | 119,447·0 | 118,908·8 | 0 | 461·2 | 77·0 |
| 92 | 125,148·0 | 124,573·6 | 0 | 505·4 | 69·0 |
| 93 | 125,121·0 | 124,667·8 | 0 | 357·5 | 95·7 |
| 94 | 125,076·0 | 124,557·8 | 0 | 426·8 | 91·4 |
| 95 | 125,090·0 | 124,642·6 | 4·0 | 388·0 | 55·4 |
| 96 | 125,133·0 | 124,676·8 | 0 | 387·4 | 68·8 |
| 97 | 124,023·3 | 123,114·8 | 103·0 | 754·5 | 51·0 |
| 98 | 124,530·0 | 123,496·4 | 531·0 | 442·4 | 60·2 |
| 114 | 125,434·0 | 124,691·2 | 280·0 | 366·2 | 96·6 |
| 115 | 125,973·0 | 125,480·4 | 0 | 423·9 | 68·7 |
| Sums. | 1,244,975·3 | 1,238,810·2 | 918·0 | 4513·3 | 733·8 |
| Percentage. | | 99·50480 | 0·07374 | 0·36252 | 0·05894 |

Hence it will be seen that about 4¼ per cent. alone of the weight is unaccounted for at once, and that, after the particles are all recovered, the amount left in the drosses is about 6 parts in 10,000, and this includes the alloy burnt away. At the rate of 1½ per cent. on the free copper, the loss on that metal would have been 607·2 tolahs, leaving only 126·6 tolahs or 0·010169 per cent. of the value as a real loss, but what is shown above fairly represents the experience of some years as regards the net loss of weight by burning.

When passed by the test of assay, the ingots go to the Laminating Department, and from this time no trustworthy valuation can be made till the coin is ready for issue. In all the succeeding processes metal is lost by abrasion and by alloy being burnt in the annealing processes and removed in the pickling necessary to clean the surface of the silver for stamping. On the other hand, oil and grease from the machinery adhere to the surfaces and (till the blanks are cleaned) a small portion of oxide adheres and thus the weight is increased.

It will be seen from the following table that the Laminators cut off and reject about 2 per cent. of the metal received, and that, very little weight being apparently lost, the outturn of good blanks is nearly 60 per cent. of the weight of ingots. Good blanks here of course meaning those which are perfect in form and ready to be tested as to their sufficiency in weight. When the whole sweeps have been refined and the silver in them recovered, there is ordinarily a gain in the Laminating Department from the causes I have spoken of. It appears that in a mean of several years the result of crediting the recoveries of sweep &c., has been a small gain in weight in these Departments, amounting to 0·00003 of the amount. It is here that the effect of bad silver is mainly felt: when silver which is derived from ornaments, and a few other sources, is used without being well refined, the floors of the laminating rooms are covered with spangles, causing of course a heavy loss, and the edges of the straps are ragged, so that the outturn of blanks is much less than the normal amount, while the weight of scissel is sensibly increased.

| Melting No. | Weight of Ingots. | Laminating. | | | Fine Rolling. | | Cutting out Blanks. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Good straps. | Ends and pieces. | Loss. | Good straps. | Loss. | Good Blanks. | Bad blanks and pieces. | Scissel. | Loss. |
| | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* | *Tolahs.* |
| 89 | 118,908·8 | 116.565·0 | 2,328·3 | 15·5 | 116,558·1 | 6·9 | 69,699·4 | 418·2 | 46,445·7 | — 5·2 |
| 92 | 124,573·6 | 122,337·5 | 2,222·5 | 13·6 | 122,333·8 | 3·7 | 73,914·0 | 310·3 | 48.071·5 | + 8·0 |
| 93 | 124,667·8 | 122,707·1 | 1,962·8 | — 2·1 | 122.704·6 | 2·5 | 74,186·2 | 265·6 | 48,240·8 | + 12·0 |
| 94 | 124,557·8 | 122,320·0 | 2,222·2 | 15·6 | 122,316·2 | 3·8 | 73,956·7 | 207·7 | 48,156·3 | — 4·5 |
| 95 | 124,642·6 | 122,386·3 | 2,241·1 | 15·2 | 122.385·2 | 1·1 | 73,946·4 | 228·9 | 48,202·1 | + 7·8 |
| 96 | 124,676.8 | 122,368·9 | 2,293·4 | 14·5 | 122,363·3 | 5·6 | 74,110·1 | 226·5 | 48,025·4 | + 1·3 |
| 97 | 123,114.8 | 120,952·8 | 2.151·6 | 10·4 | 120,950·7 | 2·1 | 73,381·0 | 314·5 | 47.267·5 | — 12·3 |
| 98 | 123.496·4 | 121,114·2 | 2,356·4 | 25·8 | 121,113·9 | 0·3 | 72,747·4 | 254·5 | 48.105·9 | + 6·1 |
| 114 | 124,691·2 | 122,230·3 | 2,448·1 | 12·8 | 122.226·1 | 4·2 | 73,075·5 | 535·1 | 48,618·8 | — 3·3 |
| 115 | 125,480·4 | 123,011·4 | 2,450·2 | 18·8 | 123,009·1 | 2·3 | 73,631·5 | 356·1 | 49.029·6 | — 8·1 |
| | 1,238,810·2 | 1,215,993·5 | 22,676·6 | 140·1 | 1,215,961·0 | 32·5 | 732,678·2 | 3117·4 | 480,163·6 | + 1·8 |
| Percentage | of Ingots, | 98·15818 | 1·83051 | ·01131 | 98·15556 | 0·00262 | 59·14370 | 0·25164 | 38·76007 | 0·00014 |
| | of Receipts, | | | | 99·99732 | 0·00267 | 60·25507 | 0 25638 | 39·48841 | 0·00014 |

The blanks when cut out pass to an officer whom we call the Adjuster whose duties are very important. After being slightly cleaned the blanks are individually weighed in Automatic Machines, the light blanks are returned to the melting pot, while those that are too heavy have their weight reduced. This used to be done by hand, but we have recently made a machine which deals satisfactorily with about 1500 blanks an hour. As the farther processes of coining reduce the weight of the blanks, an allowance has to be made here for this reduction, and it is part of the adjuster's duty not only to keep his machines in order and see that each blank is within the remedy allowed, but further to check the weights of the bags (each containing 2000 blanks) and see that each bag is within the much narrower limit laid down for his guidance, and that finally even then they are not all on one side so that the error would accumulate.

| Melting No. | Tale of Blanks. | | | | Delivery to Milling Dept. | |
|---|---|---|---|---|---|---|
| | Received. | Heavy. | Medium. | Light. | Tale. | Weight. |
| 89 | 69,662 | 2,965 | 63,933 | 2,764 | 66,000 | 66,035·9 |
| 92 | 73,890 | 2,617 | 68,928 | 2,345 | 70,000 | 70,042·5 |
| 93 | 74,124 | 3,086 | 68,790 | 2,248 | 70,000 | 70,045·0 |
| 94 | 73,906 | 2,416 | 69,283 | 2,207 | 70,000 | 70,044·0 |
| 95 | 73,896 | 2,009 | 69,959 | 1,928 | 70,000 | 70,044·6 |
| 96 | 74,056 | 1,420 | 71,277 | 1,359 | 72,000 | 72,045·4 |
| 97 | 73,300 | 3,143 | 67,971 | 2,186 | 70,000 | 70,044·1 |
| 98 | 72,684 | 2,744 | 68,232 | 1,708 | 70,000 | 70,044·1 |
| 114 | 73,024 | 3,028 | 67,783 | 2,213 | 70,000 | 70,045·5 |
| 115 | 73,582 | 1,430 | 70,847 | 1,305 | 70,000 | 70,045·5 |
| Sums. | 732,124 | 24,858 | 687,003 | 20,263 | 698,000 | 698,436·6 |
| Percentage. | | 3·39533 | 93·83697 | 2·76770 | | |

The proportion of light and heavy blanks beyond remedy is about what has now for many months been usual: the Tale of Blanks sent on is smaller in proportion, and I have not thought the percentage worth giving. Of course it includes heavy blanks reduced, but only whole bags are sent on, and thus not only has the percentage sent on been smaller but it is more regular than usual: I believe too that the weight is more regular.

The experiments were not sufficiently extensive to show the working of the machine for reducing blanks, but the following data will show this and give a comparison with the old method of filing by hand.

In December 1878, 283,639·9 Tolahs of blanks were reduced
by machine to 282,366·5

Silver removed 1,273·4

The recovery was 1243·4 Tolahs of particles worth 1173·61 Rs.,
showing a loss of 2·356 per cent. in weight of particles
and 7·836 „ „ in value of the silver

In December 1877, 233,349·8 tolahs of blanks were reduced
by filing to 232,049·4

Silver removed 1,300·4

The recovery was 1223·7 tolahs of particles worth 1129·28 Rs.,
showing a loss of 5·898 per cent. in weight of particles
and 13·236 „ „ in value of silver.

The accuracy with which a certain amount can be removed per bag has been increased and the cost greatly decreased, for one boy can attend on two machines reducing, if needed, 21,000 blanks a day, whereas this used to require ten men, and as so many were not always available, work often fell into arrears.

I have now to trace the blanks through their last stages till they become rupees.

The adjuster passes on the blanks to what is here called the Milling Department, but in the Royal Mint the work is called Marking. In this process, a few blanks are spoiled when the setting of the machines is defective. The final annealing and pickling come next, and the rupees lastly issue from the Stamping Press, only requiring examination before final issue.

I have not thought it worth while to give here the separate results in the rooms devoted to these purposes severally. Defects in the Milling Department and those in the annealing sometimes pass till they are found out in the presses or in the final scrutiny.

| | Blanks from Adjuster. | | Rupees fit for issue. | | |
|---|---|---|---|---|---|
| | Tale. | Weight. | Tale. | Weight at rate of receipt. | Weight after coinage. |
| | | Tolahs. | | Tolahs. | Tolahs. |
| 89 | 66,000 | 66,035·9 | 64,832 | | 64,834·0 |
| 92 | 70,000 | 70,042·5 | 67,940 | | 67,943·9 |
| 93 | 70,000 | 70,045·0 | 68,956 | | 68,961·9 |
| 94 | 70,000 | 70,044·0 | 69,005 | | 69,007·8 |
| 95 | 70,000 | 70,044·6 | 67,910 | | 67,911·6 |
| 96 | 72,000 | 72,045·4 | 70,459 | | 70,458·6 |
| 97 | 70,000 | 70,044·1 | 67,738 | | 67,735·8 |
| 98 | 70,000 | 70,044·1 | 68,507 | | 68,506·6 |
| 114 | 70,000 | 70,045·5 | 68,058 | | 68,057·4 |
| 115 | 70,000 | 70,045·5 | 68,407 | | 68,411·6 |
| Sums. | 698,000 | 698,436·6 | 681,812 | 682,223·4 | 681,829·2 |
| Percentage of blanks. | | | 97·68080 | Loss of weight in work. | 394·2 |

We have already seen that 59·1437 per cent. of the weight of ingots is converted into blanks. These were in tale 732,124, of which 687,003 were good and 24,858 heavy but capable of being reduced, or in all 711,861 capable of being coined, and we now find that of those sent on from the Adjusting Room 97·68080 per cent. become good Rupees. If then, all had been sent on we might have expected 695,351 good coins whose standard weight would be 56·131 per cent. of that of the ingots.

Further, we find that 681,812 blanks as they leave the adjuster lose in after processes 394·2 tolahs, or 70,956 grains, in weight. Thus the average loss on each is 0·10407* grains, and each blank leaving the adjuster should on an average weigh 180·10407 grains, and each bag of 2000 blanks 2001·156 tolahs.

The general procedure of Minting has been unchanged for very many years, but, as the effects of the coining processes must vary with details of manipulation impossible to define exactly, I some time ago recognized that it was necessary to modify both the amount of additional alloy and the excess weight of the blank over the coin, and resolved to investigate the matter.

I now offer these results to a wider circle than they were originally meant for, because I think that many will be interested in knowing the care that is taken to keep the coinage of India to its standard value. I hope too that it may lead to the publication and circulation of similar results from other Mints and thus to advance in Minting.

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* This amount, like the *y* of the fineness (see note p. 60), varies with manipulation and the quantities are dependent on each other.